

## Farmers' adaptation choices to climate change impacts and implications on agricultural productions in Kolla Temben District, Tigray Regional State, Northern Ethiopia

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**Abstract:** The main focus of this study was to identify subsistence farming communities' adaptations choices to climate change impacts and its implications on agricultural productions. The study was conducted in North Ethiopia, Tigray regional state, Kolla Temben district in 400 households. Multistage sampling was applied to select households for interview. In the first stage, 4 Kebele (administration unit) was selected randomly out of the given 27 Kebele in the district and then 400 households were selected through the probability proportional to size and simple random sampling techniques. Data on adaptations strategies that actually practiced by individual households to respond to perceived changes and total annual agricultural productions was used. Open ended and close ended questions were used to accommodate the views of all households in identifying the actual adaptation strategies practiced in the area. The adaptation strategies practiced by each farmers in response to actual impacts of climate change was statically tested to examine the correlations between households adaptation choices and agricultural productions. The commonly used and most effective adaption strategies for agriculture sector in subsistence farming communities were; use of improved varieties of crops that resists drought, diseases and pests, and water harvesting practices and access to irrigation facility. The soundness of farmer's adaptation decision determines the growth potential of agricultural production in arid and semi-arid areas.

**Keywords:** Farmers' Adaptation choices, Impacts, Agricultural productions, correlations, Food consumptions,

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Date of Submission: 23-10-2017

Date of acceptance: 18-11-2017

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### I. Introduction

Global climate changes and increasing climatic variability are likely to exert pressure on agricultural system and constraints attainments of future food production targets [1]. Sufficient knowledge of the ways in which the adverse impacts of droughts may be reduced through both mitigation and adaptation has accumulated but that knowledge has not been and is not being applied in an effective manner [2]. Household's adaptive capacity to climate change has a positive correlation with food security status [3]. Adaptation planning and implementation can be enhanced through complementary actions across levels, from individuals to governments [4]. Most of households' perceptions on temperature trend are consistent with most of research findings but do not understand its long term consequences on their livelihood bases [5]. If the global poor are to adapt to global change, it is critical to focus on poor people and not poor countries [6]. The interests of poor people are not always the same as the interests of poor countries since in the interest of 'development'; the poor may grow poorer [6]. According to [7] arguments the perspective of reducing the vulnerability of the poor through development to adapt to climate change is better than the approach of reducing the vulnerability of the poor through adaptation. Migration policy as adaption could be more useful if it accommodates changes in migration patterns that results from environmental degradation and economic crises [8]. There are certainly benefits in expanding opportunities for people to migrate as it widens people's options to respond to climate change and more generally expands their opportunities to satisfy their needs and values [9]. Adaptation is place and context-specific with no single approach for reducing risks appropriate across all settings [4]. Major crops (wheat, rice, and maize) in tropical and temperate regions are projected to be negatively impacted for local temperature increases of 2°C without adaptation [4]. There should be a ways not just to avoid a warmer world but also ways to adapt to a more uncertain world where in certain regions the risk of crop failure on a year-to-year basis is likely to increase [10]. Cultural dimensions of climate change are important for the success of adaptation and mitigation at individual and community level [11]. There is a need to integrate local knowledge into formal mitigation and adaptation policies to reduce vulnerability to climate change impacts [2]. More research is

needed on climate change impacts to improve our understanding on trees responses to climate change, quantifying the adaptive capacity of forest sector and evaluate the suitability of adaptation measures [12].

Local solutions and experiences from available adaptation measures with advanced understanding from output of fundamental research is a key to successfully adapt climate change impacts in forest [12]. Development of a methodology and a tool to help individuals, communities, countries or regions in the decision-making process towards the best response to climate change is required [13]. There is need for the households to be made aware of the interconnections that exist between climate change, food supply and health [14]. To adequately project the impacts of climate change on agriculture, adaptation should not be seen anymore as a last step in a vulnerability assessment, but as integrated part of the models used to simulate crop yields, farmers' income and other indicators related to agricultural performance [15]. No one strategy is optimal in adaptation; each has particular circumstances in which it may be more or less appropriate [16]. Farmers living in different agro ecological settings used different adaptation strategies [10]. Farmers farming experiences promote adaptation to climate change impacts [17]. Future policy should focus on providing adaptation technologies through encouraging more agro ecology based research activities [18]. This study was therefore initiated to identify the types of adaptation strategies famers are and have actually practiced in response to climate change impacts in the Kolla Temben district and; to examine whether their choices had implications on agricultural productions.

## II. Materials And Methods

One of the important concepts in the areas of climate change science is the adaptation strategies. Adaptation can be autonomous or planned one in its approach. Autonomous adaptation is a strategy that can be initiated by individual households based on the level of understanding they have on the changes. Autonomous is bottom up and real world based approach but Planned adaptation is an adaptation which is centralized, policy intervention and top-down based approach. Adaptation planning and implementation can be enhanced through complementary actions across levels, from individuals to governments [4]. Adaptation is place- and context-specific, with no single approach for reducing risks appropriate across all settings [4]. This study was therefore focused on the adaptations strategies that are practiced by individual households (bottom up approach) to respond to perceived changes. In this regard the data was collected from 400 sampled households through structured interview schedules by asking them to list out the actual adaptation strategies they were practicing to adapt to the changing climate. The researchers used open ended and close ended questions to accommodate all households' views on the adaptation strategies. Responses was coded as "0" for "No" responses and "1" for "Yes" in computer software. Finally, the adaptation strategies practiced by each farmer in responses to actual impacts of climate change was statically tested to examine the correlations between households adaptation choices and annual agricultural productions. The Chi-square statistical test was applied to examine the relationships between household's adaptation choices and agricultural productions. The types of tests used in the analysis were the 2-tailed tests. This was used to scrutinize the impact of farmer's adaptation decisions in all directions (positive or negative).

## III. Results

**Table 1.** Household's adaptation strategies to climate change in agriculture sector

Lists of locally practiced adaptation strategies to climate change impacts	Households status in using these adaptation strategies in response to climate change impacts				Total		Missed value	
	No		Yes		no	%	no	%
	No	%	No	%				
Planting different varieties of crops as adaptation strategies	19	4.8	375	93.8	394	98.5	6	1.5
Using different planting dates as adaptation strategies	45	11.3	350	87.5	395	98.8	5	1.3
Diversifying farm activities as adaptations	89	22.3	302	75.5	391	97.8	9	2.3
Change from crop production to livestock production as adaptation strategies	160	40.0	234	58.5	394	98.5	6	1.5
Change livestock to crop production as adaptation strategies	300	75.0	95	23.8	395	98.8	5	1.3
using irrigation facility as adaptation strategies	331	82.8	64	16.0	395	98.8	5	1.3
Practicing soil conservations as adaptation strategies	294	73.5	101	25.3	395	98.8	5	1.3
Used drainage as adaptation strategies	102	25.5	291	72.8	393	98.3	7	1.8
Used short gestation crops as adaptation strategies	191	47.8	205	51.3	396	99.0	4	1.0

Used flood tolerant crops as adaptation strategies	182	45.5	214	53.5	396	99.0	4	1.0
Disease or/and pest resistant crop varieties as adaptation strategies	129	32.3	267	66.8	396	99.0	4	1.0
Water harvest practices as adaptation strategies	145	36.3	250	62.5	395	98.8	5	1.3

Sources; field Study results, 2016/17

**Table 2.** Correlations tests between household's adaptations strategies and total household income from crops

		Household's total annual income from crops in ETB	households used drought tolerant crop varieties as adaptation strategies to climate change
Households total annual income from crops production in ETB	Pearson Correlation	1	.131**
	Sig. (2-tailed)		.009
	N	397	393
Households used drought tolerant crop as adaptation strategies to climate change	Pearson Correlation	.131**	1
	Sig. (2-tailed)	.009	
	N	393	396

\*\* Correlation is significant at the 0.01 level (2-tailed).

Sources; field Study results, 2016/17

**Table 3.** Correlations tests between household's adaptations strategies and total household food consumption in kg

		Household annual food consumption in kg	Households using irrigation facility as adaptation strategies to climate change
Household annual food consumption in kg	Pearson Correlation	1	.099
	Sig. (2-tailed)		.051
	N	396	391
Households using irrigation facility as adaptation strategies to climate change	Pearson Correlation	.099	1
	Sig. (2-tailed)	.051	
	N	391	395

Sources; field Study results, 2016/17

**Table 4.** Relationship tests between household's adaptations strategies used irrigation facility as adaptation strategies to climate change and total household crop production in Kg

		Households using irrigation facility as adaptation strategies to climate change	Household total annual crop production in Kg
Households using irrigation facility as adaptation strategies to climate change	Pearson Correlation	1	.093
	Sig. (2-tailed)		.067
	N	395	391
Households total annual total crop productions in Kg	Pearson Correlation	.093	1
	Sig. (2-tailed)	.067	
	N	391	396

Sources; field Study results, 2016/17

**Table 5.** Correlations tests between household's adaptations strategies used drought tolerant crop varieties as adaptation strategies to climate change impacts and household total food consumptions from own harvest in kg

		Households used drought tolerant crop as adaptation strategies to climate change	Household total annual food consumption in kg
Households used drought tolerant crop as adaptation strategies to climate change	Pearson Correlation	1	.055
	Sig. (2-tailed)		.276
	N	396	394
Household total annual food consumption in kg	Pearson Correlation	.055	1
	Sig. (2-tailed)	.276	
	N	394	398

\*Correlation is significant at less than 0.10

Sources; field Study results, 2016/17

**Table 6.** Correlation tests between household's adaptations strategies used drought tolerant crop varieties as adaptation strategies to climate change impacts and household total annual crop sells in market

		households used drought tolerant crop as adaptation strategies to climate change	household total annual crop sells in Kg
Households used drought tolerant crop as adaptation strategies to climate change	Pearson Correlation	1	.007
	Sig. (2-tailed)		.891
	N	396	383
Households total annual crop sells in Kg	Pearson Correlation	.007	1
	Sig. (2-tailed)	.891	
	N	383	386

\*\*\*. Correlation is significant at the 0.01 level (2-tailed).

Sources; field Study results, 2016/17

**Table 7.** Correlations tests between household's adaptations strategies used disease or pest resistant crop varieties as adaptation strategies to climate change impacts and household total incomes from crops in ETB

		Household total annual income from crops in ETB	Households used disease or pest resistant varieties as adaptation strategies to changing climate impact
Household total annual income from crops in ETB	Pearson Correlation	1	.144***
	Sig. (2-tailed)		.004
	N	397	393
Households used disease or pest resistant varieties as as adaptation strategies to changing climate impact	Pearson Correlation	.144***	1
	Sig. (2-tailed)	.004	
	N	393	396

\*\*\*. Correlation is significant at the 0.01 level (2-tailed).

Sources; field Study results, 2016/17

**Table 8.** Correlation tests between household's adaptations strategies used water harvest practices as adaptation strategies to climate change impacts and household total incomes from crops in ETB

		Household's total annual income from crops in ETB	Households used water harvest practices as adaptation strategies to climate change
Household's total annual income from crops in ETB	Pearson Correlation	1	.112*
	Sig. (2-tailed)		.026
	N	397	392
Households used water harvest practices as adaptation strategies to climate change	Pearson Correlation	.112*	1
	Sig. (2-tailed)	.026	
	N	392	395

\*. Correlation is significant at the 0.05 level (2-tailed).

Sources; field Study results, 2016/17

**Table 9.** Correlations tests between household's adaptations strategies used flood tolerant crops as adaptation strategies to climate change impacts and household total crop productions in Kg

		Household's total annual crop production in Kg	Household 's use flood tolerant crops as adaptation strategies to climate change
Household's total annual crop production in Kg	Pearson Correlation	1	.012
	Sig. (2-tailed)		.806
	N	396	392
Household use flood tolerant crops as adaptation strategies to climate change	Pearson Correlation	.012	1
	Sig. (2-tailed)	.806	
	N	392	396

\*. Correlation is significant at the 0.05 level (2-tailed).

Sources; field Study results, 2016/17

**Table 10.** Correlations tests between household's adaptations strategies used drought tolerant crop as adaptation strategies to climate change impacts and household total income from crops in ETB

		Households total annual income from crops in ETB	Households used drought tolerant crop as adaptation strategies to climate change
Household's total annual income from crops in ETB	Pearson Correlation	1	.131**
	Sig. (2-tailed)		.009
	N	397	393
Households used drought tolerant crop as adaptation strategies to climate change	Pearson Correlation	.131**	1
	Sig. (2-tailed)	.009	
	N	393	396

\*\* . Correlation is significant at the 0.01 level (2-tailed).

Sources; field Survey results, 2016/17

**Table 11.** Correlations tests between household's adaptations strategies used drought tolerant crop varieties as adaptation strategies to climate change impacts and household total crop production in Kg

		hh total annual crop production in Kg	household changed from livestock to crop production as adaptation strategies to climate change
Household's total annual crop production in Kg	Pearson Correlation	1	.016
	Sig. (2-tailed)		.759
	N	396	391
Household's changed from livestock to crop production as adaptation strategies to climate change	Pearson Correlation	.016	1
	Sig. (2-tailed)	.759	
	N	391	395

\*. Correlation is significant at the 0.05 level (2-tailed).

Sources; field Study results, 2016/17

**Table 12.** Correlation tests between household's adaptations strategies used changing from crop production to livestock production and household total crop production in Kg

		hh total crop production in Kg	households changed from crop production to livestock production as adaptation strategies to climate change
Household's total annual crop production in Kg	Pearson Correlation	1	.124*
	Sig. (2-tailed)		.014
	N	396	390
Household's changed from crop production to livestock production as adaptation strategies to climate change	Pearson Correlation	.124*	1
	Sig. (2-tailed)	.014	
	N	390	394

\*. Correlation is significant at the 0.05 level (2-tailed).

Sources; field Study results, 2016/17

**Table 13.** Correlation tests between household's adaptations strategies used different planting dates as adaptation strategies to changing climate impacts and household total annual crop production in Kg

		Household's total crop production in Kg	Households using different planting dates as adaptation strategies to changing climate
Household's total annual crop production in Kg	Pearson Correlation	1	.027
	Sig. (2-tailed)		.598
	N	396	391
Households using different planting dates as adaptation strategies to changing climate	Pearson Correlation	.027	1
	Sig. (2-tailed)	.598	
	N	391	395

Sources; field Study results, 2016/17

#### IV. Discussions

Many farmers were found using different types of adaptation strategies to cope with climate change impacts. Mostly practiced adaptation strategies in the agriculture sector in the kola Temben district were; use of different crop varieties (93.8%), applications of different planting dates (87.5 %), diversifying farm activities (75.5%), shifting of production areas (from crop to livestock (58.5%), livestock to crop production (23.5%) ), use of irrigation facilities (16%), use of pest resistant crops (66%), and water harvesting practices (62.5). The least practiced adaptation strategy in the area was the use of irrigation facility (16 %), (Table, 1).

The result in Table 2 revealed that there was a statistically significant positive correlations between the usage of drought tolerant crop varieties as adaptation strategies and total annual income from crop productions ( $r=.131$ ,  $p<.01$ ). Households who used drought tolerant crop varieties as an adaptation strategy to climate change impact was found getting higher incomes than those not used (Table, 2).

The research finding revealed that there was a statistically significant positive correlations between use of irrigation facility as adaptation to climate change impacts and household's annual total food consumption amount ( $r=.099$ ,  $p<.010$ ). Households with an access to irrigation facilities had a high probability of to feed family from own harvest and to consume more food (Table, 3).

The study found that access to irrigation facility and total annual crop productions had statistically significant positive correlation ( $r=.159$ ,  $p<.001$ ). Households with more access to irrigation facility were found with higher annual crop production. Irrigation facility had significant impacts on household's annual total crop productions (Table,4).

The study result in Table 5 found that there was a statistically significant positive correlations between the usage of drought tolerant crop varieties as adaptation strategies and household's annual total food consumptions ( $r=.055$ ,  $p<.010$ ). This result revealed that households which used drought tolerant crop varieties as adaptation strategies to climate change were found consuming more food. This makes clear that household's consumption pattern was impacted by household's adaption strategies (Table, 5).

This study also make clear that that there was significant positive correlation between the use of drought tolerant crop variety as adaptation strategies and households' total annual crop sell ( $r=.891$ ,  $p<.01$ ). Household's adaptation strategies had impacts on market stability. The study also revealed that household's adaptation decisions had direct impacts on the availability of agricultural production in a market (Table, 6).

The field study result in Table7revealed that there was a statistically significant positive correlations between the use of pest resistant crop varieties as adaptation strategies and household's total annual incomes from crop productions ( $r=.144$ ,  $p<.01$ ). The use of crop variety that can resist pests and disease outbreak was found as the effective adaption strategies to improve crop productivity under all the stress of climate change (Table, 7).

The study result in Table 8 clearly shows that there was a statistically significant positive correlation between household water harvesting practices and household's total income from crop productions ( $r=.159$ ,  $p<.001$ ). Water harvesting practices was found as one of the effective adaptation strategies to climate change impacts in the agriculture sector. Water harvesting practices and agricultural productivity had a direct and positive correlation (Table, 8).

Flood is one of the climate change related impacts and affects agricultural productivity and production. The field study result in Table 9 revealed that there was a statistically significant positive correlations between use of flood tolerant crop varieties as adaptation strategies to climate change impacts and total annual crop production ( $r=.806$ ,  $p<.05$ ).

Drought is one of the climate change related factors that determine agricultural production. Effective adaption strategy is very important to sustain the productivity of the agriculture sector and to feed the fast growing population. The study result in Table 10 clearly revealed that there was a statistically significant positive correlations between the use of drought tolerant crop varieties as adaptation strategies to climate change impacts and total annual income from crop production ( $r=.131$ ,  $p<.01$ ).

The aim of this analysis was to see if household's adaptation decisions to shifting production areas from livestock rearing to crop productions had impact on total agriculture productions. The field study result in Table 11 revealed that there was a statistically significant positive correlations between total annual crop production and shifting of productions areas from livestock to crop production as adaptation strategies to climate change ( $r=.759$ ,  $p<.05$ ). Households who changed their agricultural focus from livestock rearing to crop productions were found with more total harvest (Table, 11).

This study also reveal that household's decisions to change from crop production to livestock rearing as adaptation strategies to climate change impact had statistically significant positive correlations with total annual crop production they got ( $r=.124$ ,  $p<.05$ ). Decisions to change the types of agricultural activities as adaptation strategies to the stimulus of climate were found as one of the effective area specific strategies to cope with the adverse impact of climate change (Table, 12).

The use of different planting dates as adaptation strategies to climate change impacts had a statistically significant positive correlations with annual total crop production ( $r=.598$ ,  $p<.05$ ). Managing the date when crops should be planted was found having a positive contribution to the annual increments of crop production and productivity per spot of land (Table, 13).

## **V. Conclusions**

Farmers are using their own adaptation strategies to cope with the impacts of climate change. The commonly used and most effective adaption strategies in the agriculture sector are; use of improved varieties of crops that resists drought, diseases and pests. Water harvesting practices and access to irrigation facility are the most effective adaptation strategies for subsistence farming communities. The soundness of farmer's adaptation decision determines the growth potential of agricultural production in arid and semi-arid areas. Agriculture sector becomes very sensitive to climate change impacts and it is easily affected by climate variability. Household's ability to adapt to climate impacts become very important to sustained agricultural production and to feed a family in particular and a nation in general. Household's adaptation choices are one of the major determinants of household's annual total income earn from the agriculture sector. Future development policy should consider the importance of addressing climate impacts and having mechanisms to reduce household's vulnerability to climate change impacts. Further research on the impacts of climate change at different agro-ecological zones, crop varieties, animal species and possible human interventions to facilitate adaptation and moderate damage is very vital. More research works on the options of 'no regret adaptation' approach is very curial to guide future development policy under the uncertain global climate system.

## **Acknowledgements**

Authors of this research article would like to express their appreciation to the Mekelle University for the research fund support.

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Alemu Addisu Farmers' adaptation choices to climate change impacts and implications on agricultural productions in Kolla Temben District, Tigray Regional State, Northern Ethiopia." IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT), vol. 11, no. 10, 2017, pp. 39-45